

What is claimed is:

- 1 1. An apparatus for sensing seismic waves in the earth, the apparatus
2 comprising:
3 (a) a housing;
4 (b) one or more seismic sensors disposed in the housing; and
5 (c) at least one isolator coupled to the one or more seismic
6 sensors for isolating the one or more seismic sensors from high-g
7 shock induced in the housing.
- 1 2. The apparatus of claim 1, wherein the at least one isolator is disposed to
2 provide isolation from the induced vibrations in at least one predetermined
3 direction.
- 1 3. The apparatus of claim 1 further comprising an electronics package
2 disposed in the housing and wherein the at least one sensor form at least a
3 portion of the electronics package.
- 1 4. The apparatus of claim 2, wherein the at least one predetermined direction
2 further comprises directions along three translational axes and three angular
3 axes.
- 1 5. The apparatus of claim 1, wherein the at least one isolator further
2 comprises a layer of silicone rubber.
- 1 6. The apparatus of claim 1, wherein the at least one isolator further
2 comprises a layer of polyurethane foam.

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1 7. The apparatus of claim 1, wherein the at least one isolator further
2 comprises a first layer of silicone rubber and a second layer of polyurethane
3 foam.

1 8. The apparatus of claim 1 further comprising a block as an inertial mass
2 operatively associated with the one or more sensors.

1 9. The apparatus of claim 1, wherein the one or more sensors are
2 accelerometers.

1 10. The apparatus of claim 9, wherein the one or more accelerometer sensors
2 are three accelerometers disposed to provide three orthogonal axes of
3 sensitivity.

1 11. The apparatus of claim 9, wherein the one or more accelerometers are
2 MEMS accelerometers.

1 12 The apparatus of claim 1 further comprising a cap coupled to the housing,
2 the cap having a feedthrough for providing conductor access to the one or more
3 seismic sensors.

1 13. The apparatus of claim 12, wherein the cap and housing are coupled to
2 form a sealed sensor module.

1 14. The apparatus of claim 13, wherein the sealed sensor module is
2 hermetically sealed.

1 15. A seismic sensor module tolerant to high-g shock inputs comprising:
2 (a) a module case;

- 3 (b) a sensor assembly housed by the module case, wherein the sensor
4 assembly includes an inertial mass and at least one seismic sensor
5 coupled to the inertial mass; and
6 (c) at least one isolator coupled to the sensor assembly and the
7 module case.

1 16. The seismic sensor module of claim 15, wherein the module case is
2 adapted to provide a compressive force on the at least one isolator.

1 17. The sensor module of claim 15, wherein the at least one seismic sensor is
2 a MEMS accelerometer.

1 18. The sensor module of claim 15, wherein the at least one isolator is
2 disposed to provide isolation from the induced vibrations in at least one
3 predetermined direction.

1 19. The sensor module of claim 18, wherein the at least one predetermined
2 direction further comprises directions along three translational axes and three
3 angular axes.

1 20. The sensor module of claim 15, wherein the at least one isolator further
2 comprises a layer of silicone rubber.

1 21. The sensor module of claim 15, wherein the at least one isolator further
2 comprises a layer of polyurethane foam.

1 22. The sensor module of claim 15, wherein the at least one isolator further
2 comprises a first layer of silicone rubber and a second layer of polyurethane
3 foam.

1 23. The sensor module of claim 17, wherein the at least one MEMS
2 accelerometer further comprises three MEMS accelerometers disposed to
3 provide three orthogonal axes of sensitivity.

1 24. The sensor module of claim 15 further comprising a cap coupled to the
2 module case, the cap having a feedthrough for providing conductor access to the
3 one or more seismic sensors.

1 25. The sensor module of claim 24, wherein the cap and module case are
2 sealed.

1 26. The sensor module of claim 25, wherein the sealed sensor module is
2 hermetically sealed.

1 27. A seismic sensor module comprising:
2 (a) a module case; and
3 (b) a sensor assembly coupled to the module case, the sensor
4 assembly including one or more seismic sensors; and
5 (c) an inertial mass coupled to the sensor assembly for
6 providing noise reduction in the sensor module.

1 28. The seismic sensor module of claim 27, wherein the inertial mass is a
2 block of metal.

1 29. The seismic sensor module of claim 27, wherein the one or more sensors
2 are accelerometers.

1 30. The seismic sensor module of claim 29, wherein the one or more
2 accelerometers are three accelerometers disposed to provide three orthogonal
3 axes of sensitivity.

1 31. The seismic sensor module of claim 29, wherein the one or more
2 accelerometers are MEMS accelerometers.

1 32. The sensor module of claim 27 further comprising a cap coupled to the
2 module case, the cap having a feedthrough for providing conductor access to the
3 one or more seismic sensors.

1 33. The sensor module of claim 32, wherein the cap and module case are
2 sealed.

1 34. The seismic sensor module of claim 33, wherein the sealed sensor
2 module is hermetically sealed.

1 35. A sensor module tolerant to high-g shock inputs comprising:
2 (a) a module case;
3 (b) a sensor assembly within the module case, the sensor assembly
4 having an inertial mass coupled to the module case and at one or
5 more seismic sensors coupled to the inertial mass; and
6 (c) an isolation layer coupled to the module case and to the sensor
7 assembly, wherein the sensor assembly does not move relative to
8 the module case when an input force of less than a predetermined
9 level is applied to the module case.

1 36. The sensor module of claim 35, wherein the predetermined level is 1g.

1 37. The sensor module of claim 35, wherein the at least one isolator is
2 disposed to provide isolation from the induced vibrations in at least one
3 predetermined direction.

1 38. The sensor module of claim 37, wherein the at least one predetermined
2 direction further comprises directions along three translational axes and three
3 angular axes.

1 39. The sensor module of claim 35, wherein the at least one isolator further
2 comprises a layer of silicone rubber.

1 40. The sensor module of claim 35, wherein the at least one isolator further
2 comprises a layer of polyurethane foam.

1 41. The sensor module of claim 35, wherein the at least one isolator further
2 comprises a layer of silicone rubber and a layer of polyurethane foam.

1 42. The sensor module of claim 35, wherein the one or more sensors are
2 accelerometers.

1 43. The sensor module of claim 35, wherein the one or more sensors are
2 three accelerometers disposed to provide three orthogonal axes of sensitivity.

1 44. The sensor module of claim 35, wherein the one or more sensors are
2 MEMS accelerometers.

1 45. The sensor module of claim 35 further comprising a cap coupled to the
2 module case, the cap having a feedthrough for providing conductor access to the
3 one or more seismic sensors.

1 46. The sensor module of claim 45, wherein the cap and module case are
2 sealed.

1 47. The sensor module of claim 46, wherein the sealed sensor module is
2 hermetically sealed.

1 48. A method of isolating one or more seismic sensor in a seismic sensor
2 module from high-g shock loads while maintaining sensitivity to seismic waves,
3 the method comprising:

- 4 (a) providing a housing for the seismic sensor assembly;
5 (b) installing one or more seismic sensors in the housing;
6 (c) providing at least one isolator between the one or more sensors
7 and the housing.

1 49. The method of claim 48 further comprising coupling an inertial mass to the
2 one or more seismic sensors.

1 50. The method of claim 48, wherein the at least one isolator is disposed to
2 provide isolation from the induced vibrations in at least one predetermined
3 direction.

1 51. The method of claim 50, wherein the at least one predetermined direction
2 further comprises directions along three translational axes and three angular
3 axes.

1 52. The method of claim 48, wherein providing the at least one isolator further
2 comprises providing a layer of silicone rubber.

1 53. The method of claim 48, wherein providing the at least one isolator further
2 comprises providing a layer of polyurethane foam.

1 54. The method of claim 48, wherein providing the at least one isolator further
2 comprises providing a layer of silicone rubber and a layer of polyurethane foam.

1 55. The method of claim 48 further comprising reducing noise during
2 operation of the sensor module using an inertial mass coupled to the one or more
3 sensors.

1 56. The method of claim 48, wherein the one or more sensors are
2 accelerometers.

1 57. The method of claim 48, wherein the one or more sensors are three
2 accelerometers disposed to provide three orthogonal axes of sensitivity.

1 58. The method of claim 48, wherein the one or more sensors are MEMS
2 accelerometers.

1 59 The method of claim 48, wherein the sensor assembly further comprises a
2 cap coupled to the housing, the cap having a feedthrough for providing conductor
3 access to the one or more seismic sensors, the method further comprising
4 sealing the cap and housing to form a sealed sensor module.

1 60. The method of claim 59, wherein the sealed sensor module is hermetically
2 sealed.